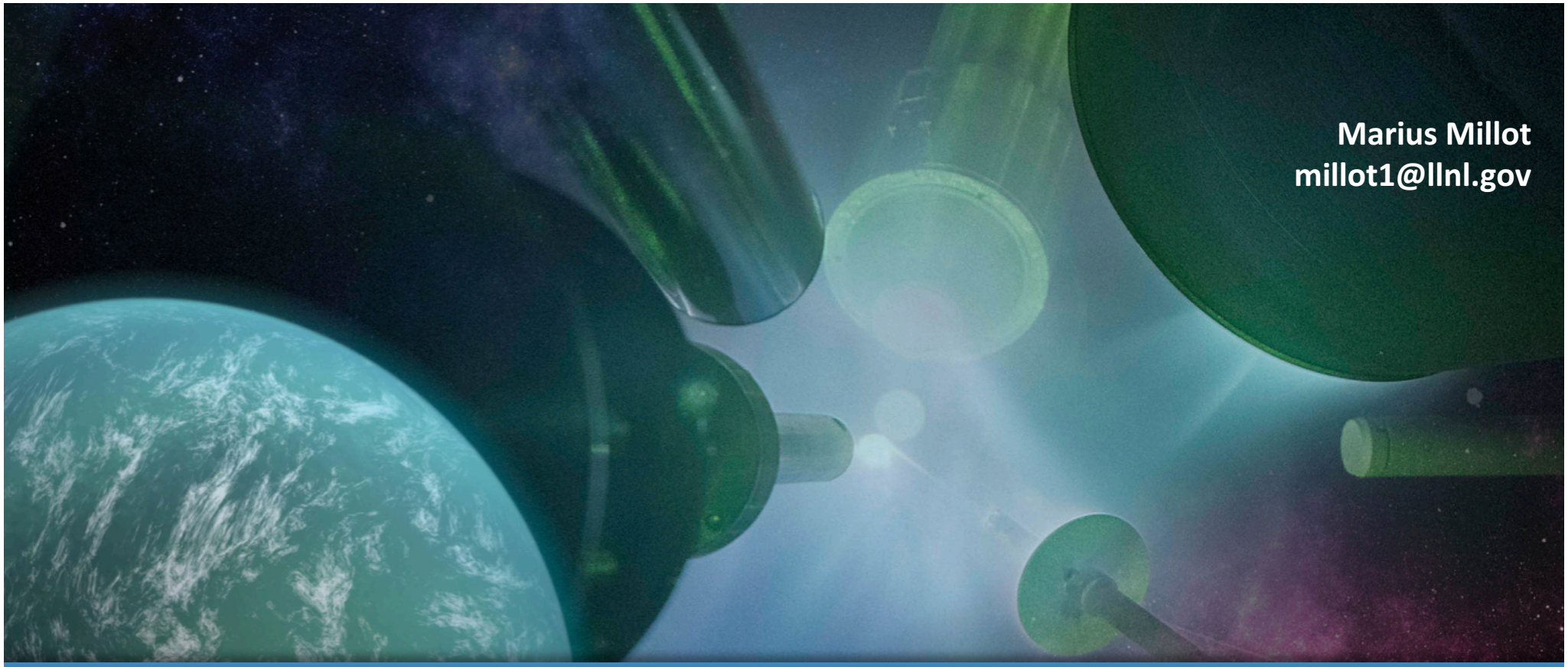
Dynamic Compression with sub-kJ Lasers at photon facilities

Workshop on Studies of
Dynamically **Co**mpressed **Ma**tter with **X**-rays
29 and 30 March 2017 - ESRF Auditorium



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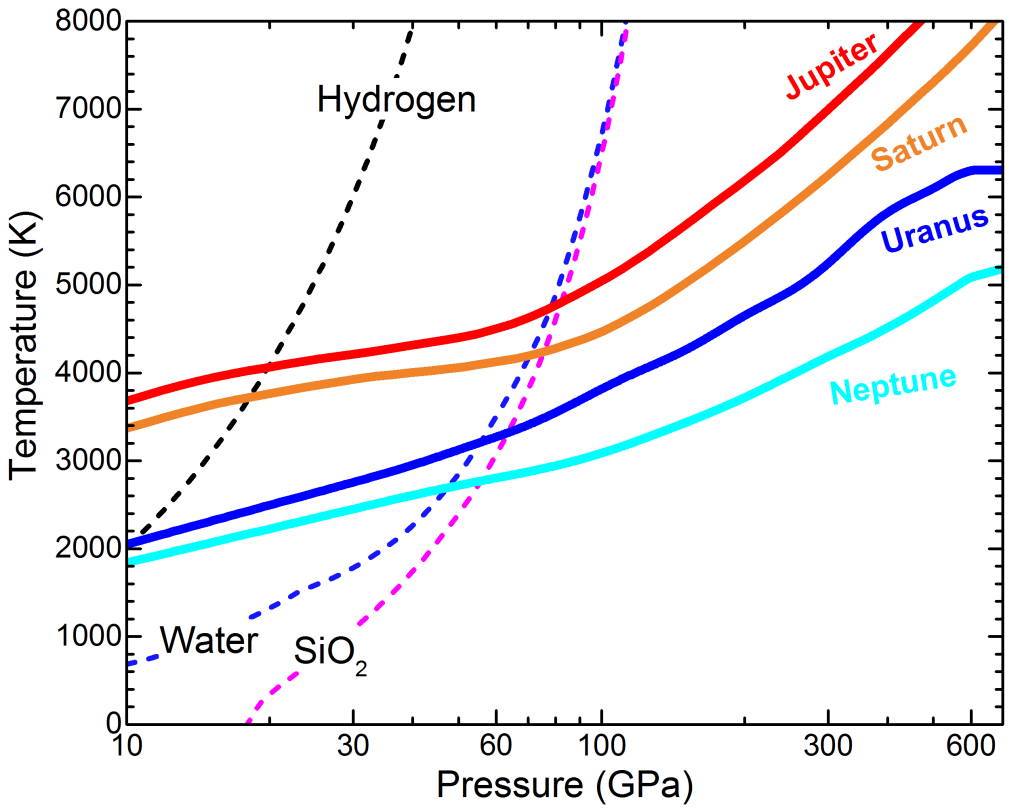
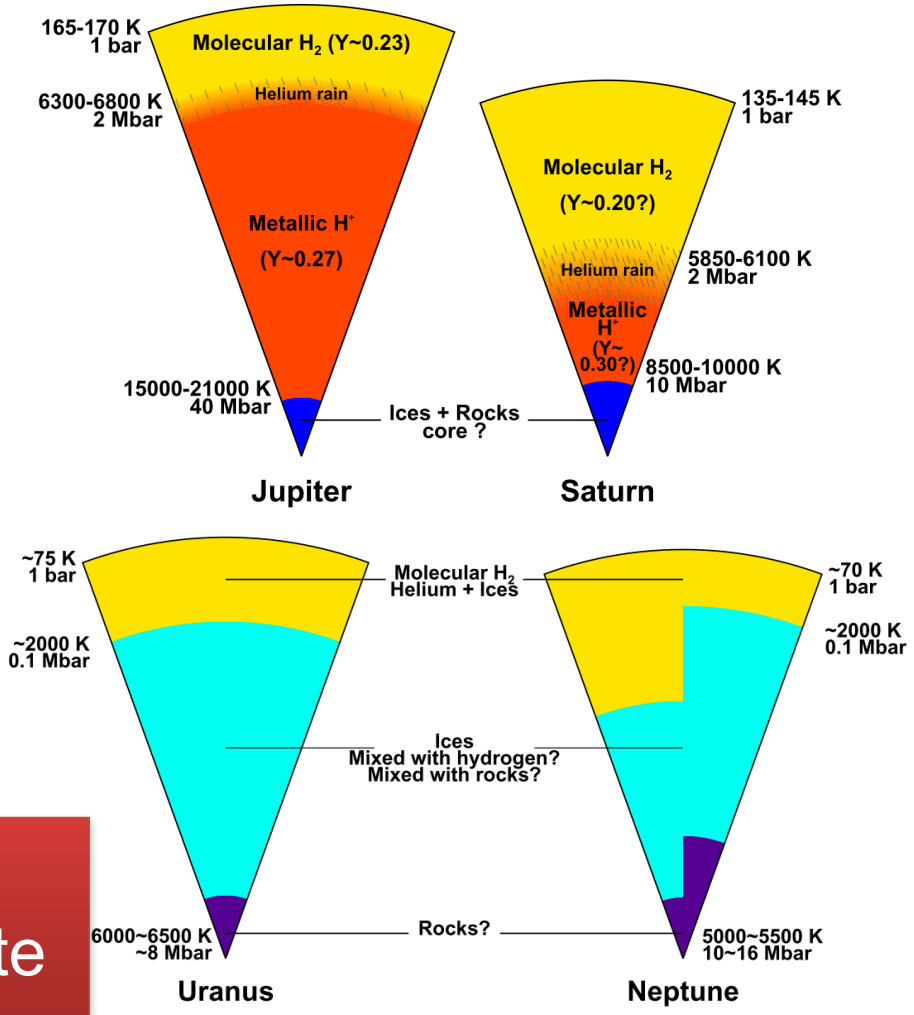
Laser driven shocks can reach very high pressure but shock temperatures of planetary materials are much larger than planetary interior temperatures above 0.5-1 Mbar



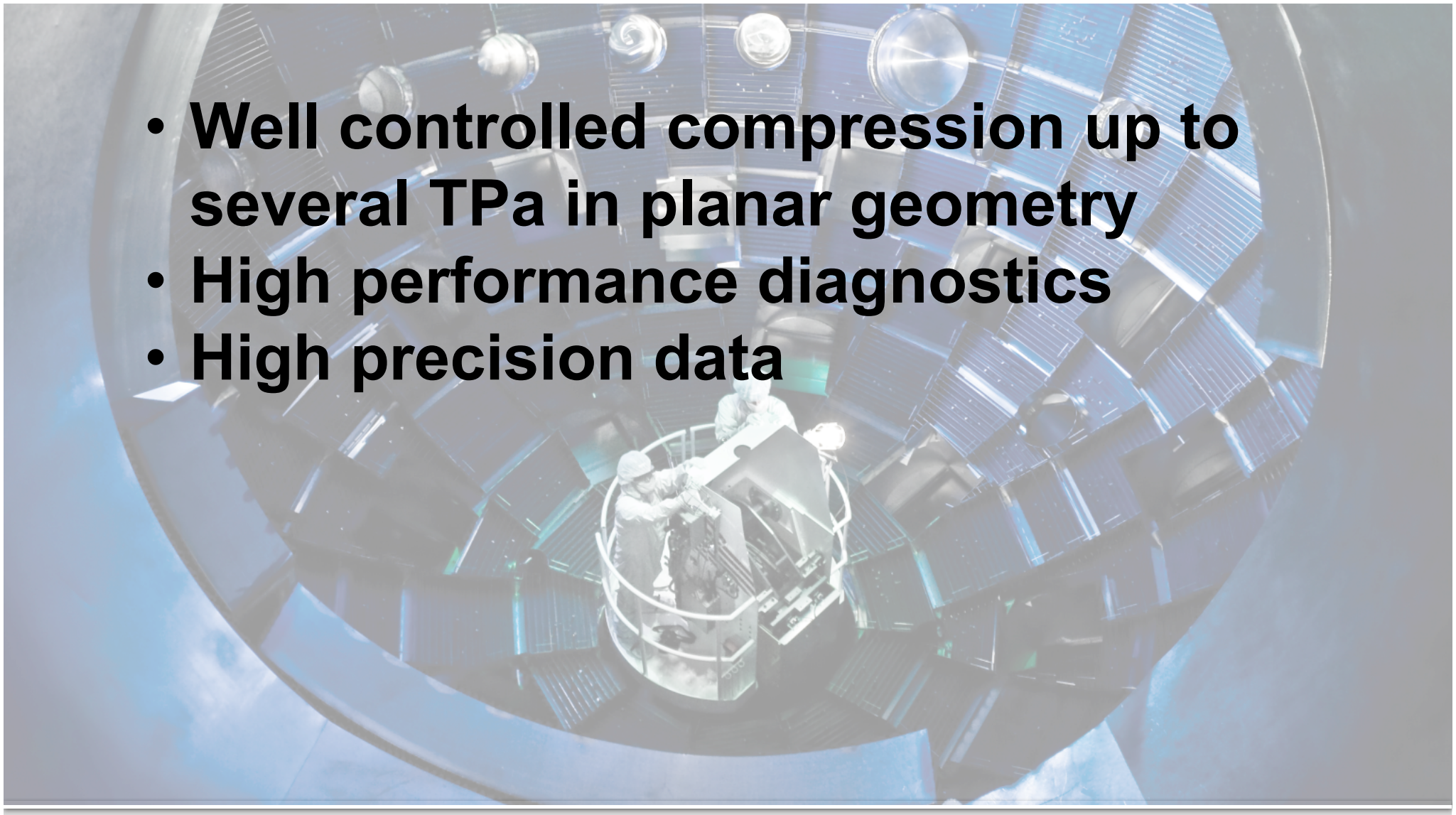


Need "*smarter*" advanced dynamic compression techniques to recreate planetary interior conditions

[Militzer2013, Nettelmann2013, Guillot2014]

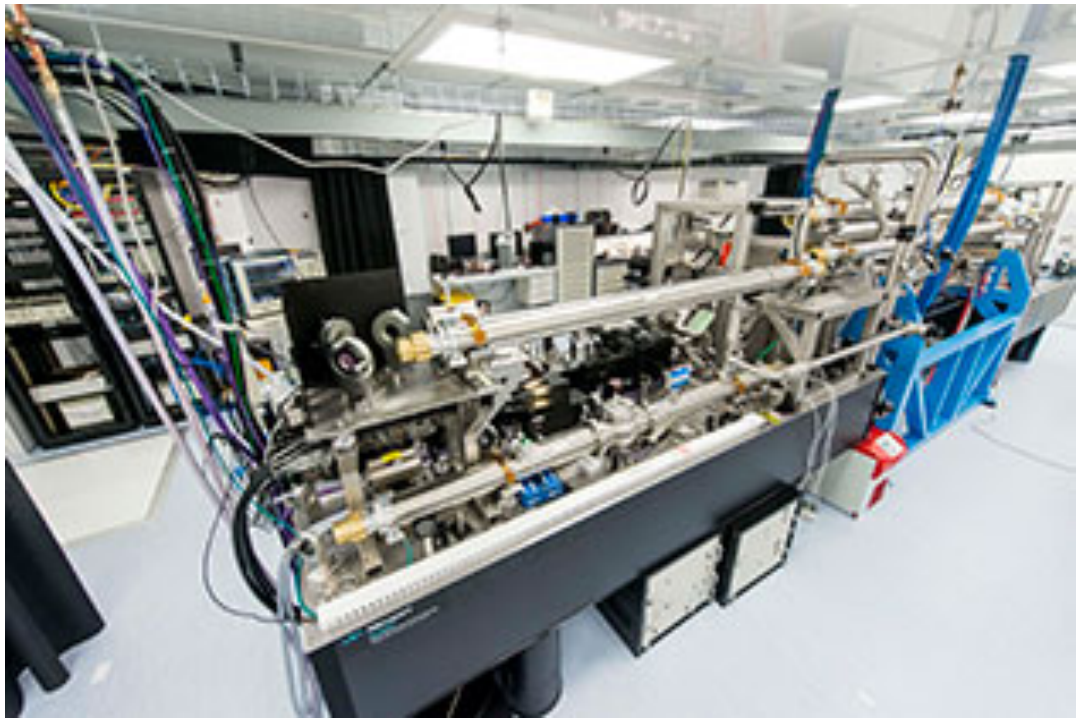
Advanced dynamic compression on large multi-kJ lasers

Advanced dynamic compression on large multi-kJ lasers



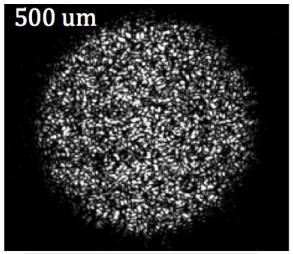
- **Well controlled compression up to several TPa in planar geometry**
- **High performance diagnostics**
- **High precision data**

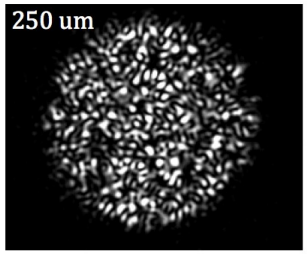
Dynamic compression with sub-kJ lasers at photon facilities

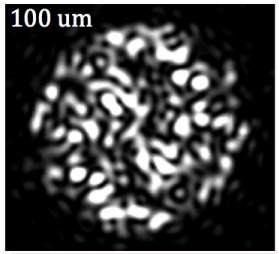


Sub-kJ laser can generate high pressures, BUT … there are intrinsic limitations

- Mitigating Laser Imprint, typical speckle > several microns





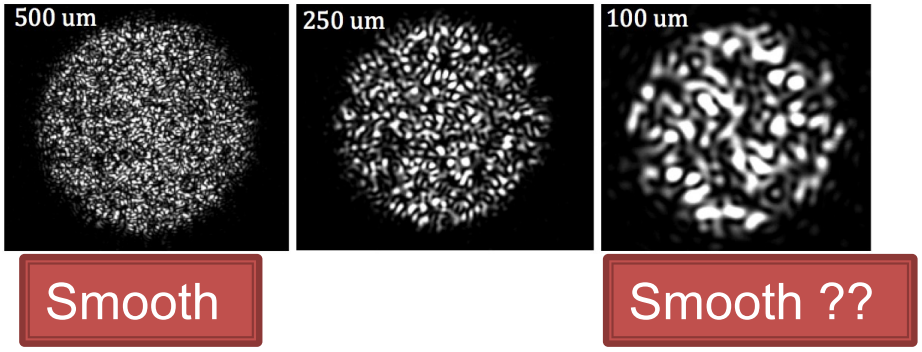


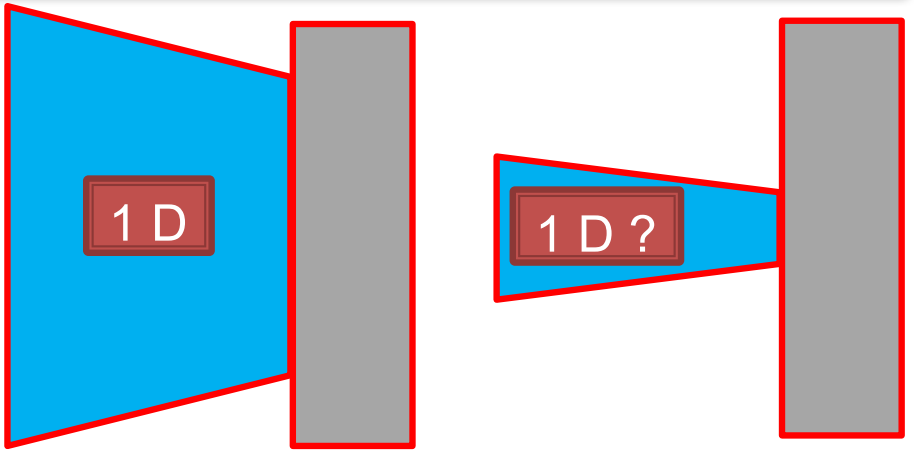
Smooth

Smooth ??

Sub-kJ laser can generate high pressures, BUT … there are intrinsic limitations

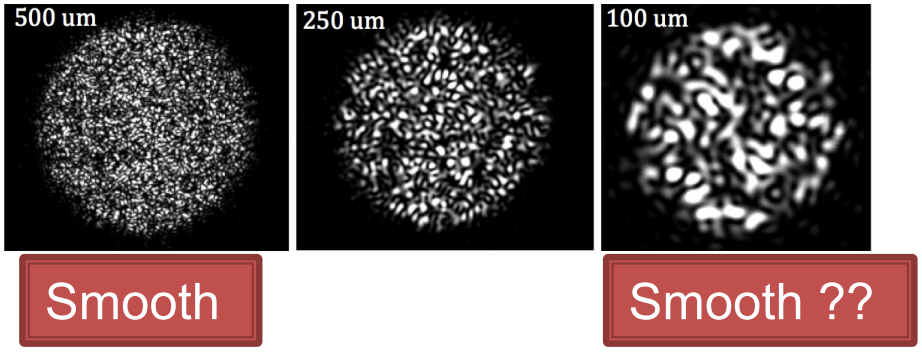
- Mitigating Laser Imprint, typical speckle > several microns
- Reducing the “transverse dimension” to get multi-Mbar Pressure

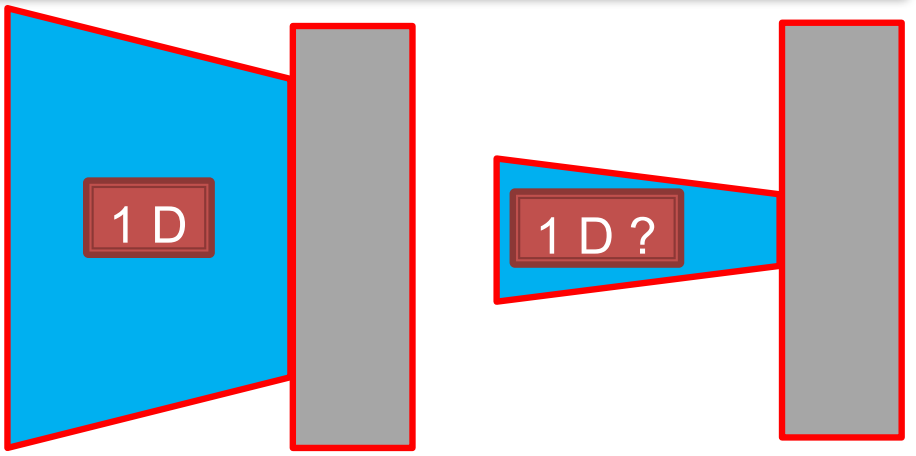




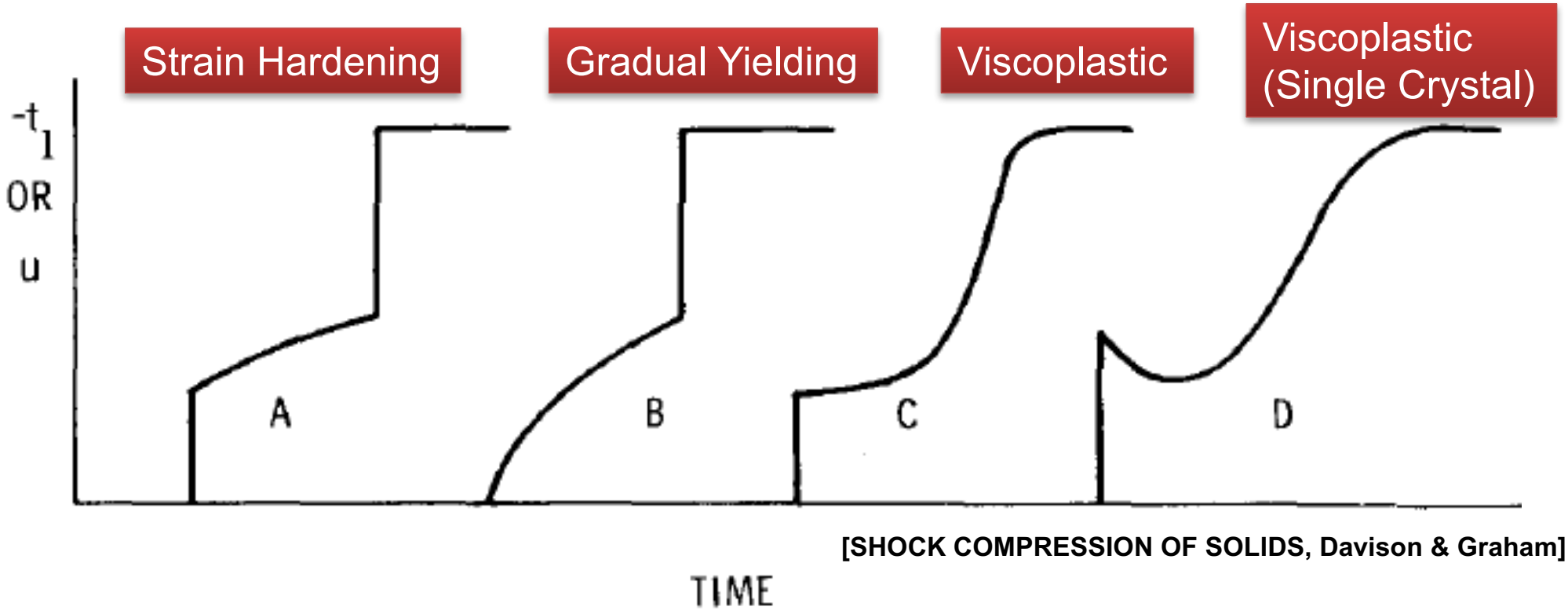
Sub-kJ laser can generate high pressures, BUT … there are intrinsic limitations

- Mitigating Laser Imprint, typical speckle > several microns
- Reducing the "transverse dimension" to get several Mbar
  →**Need thinner targets** to maintain 1D propagation→ Need for:
  – Higher precision in **Target Fabrication** **$$$**
  – **Faster,** high sensitivity **diagnostics** for velocimetry **$$$**
  – High **co-timing** accuracy between x-rays and Drive **$$$**





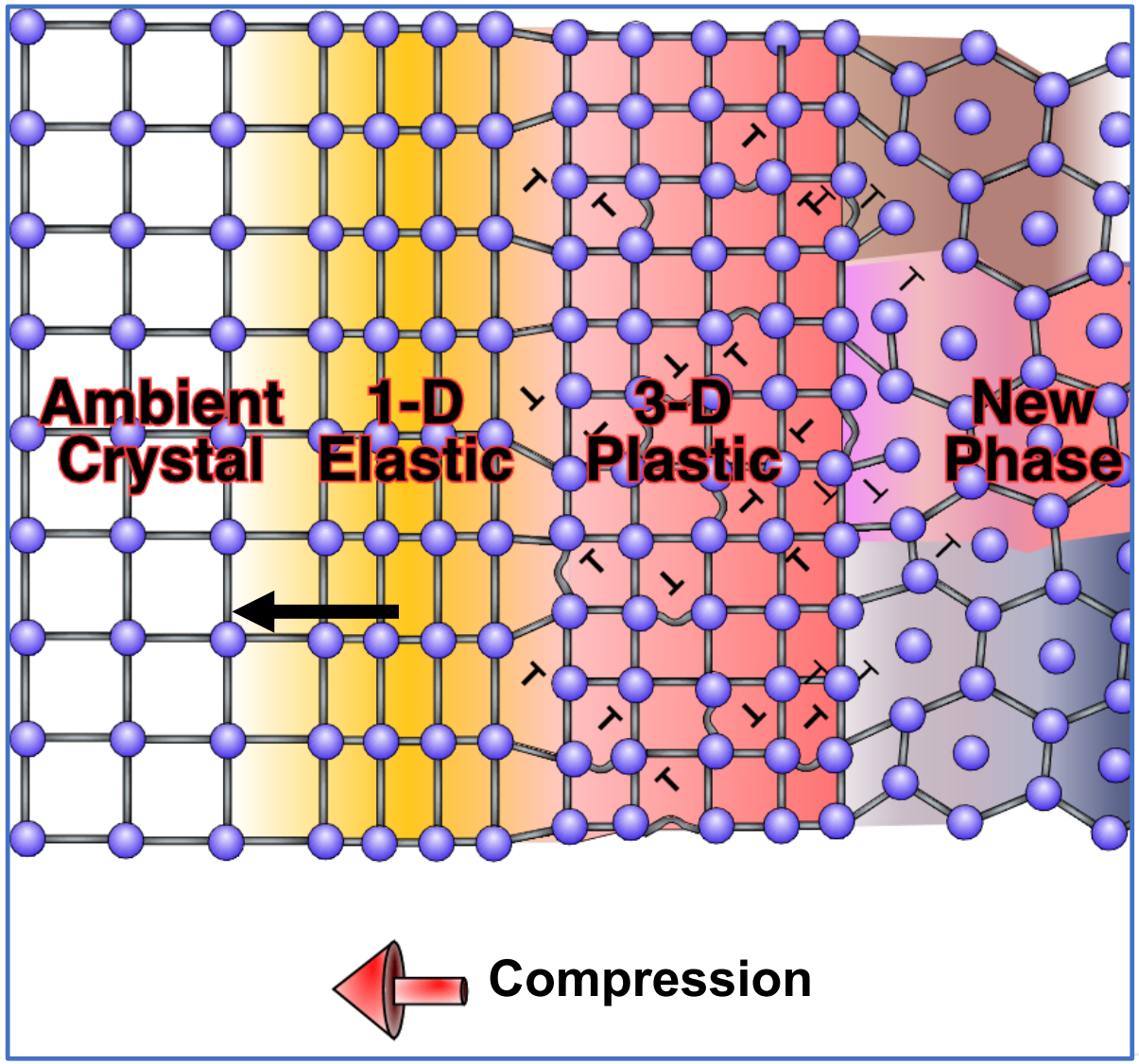
For 50 years the research on dynamic compressed materials has mostly relied on wave profile analysis



[SHOCK COMPRESSION OF SOLIDS, Davison & Graham]

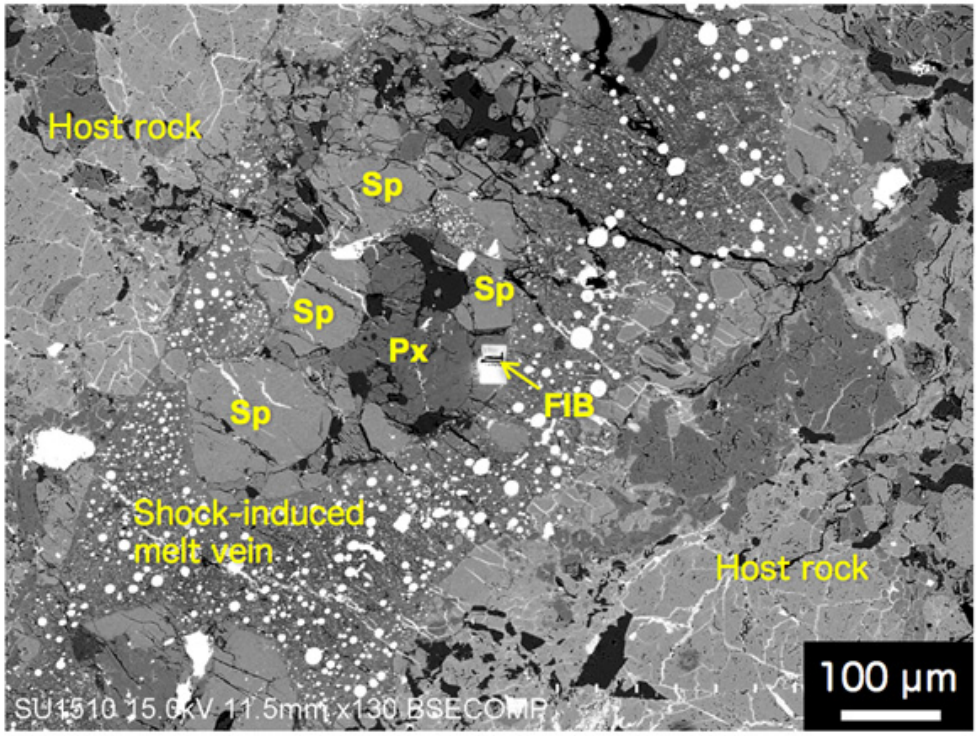
We now have the opportunity to probe these phenomena at the microscopic scale

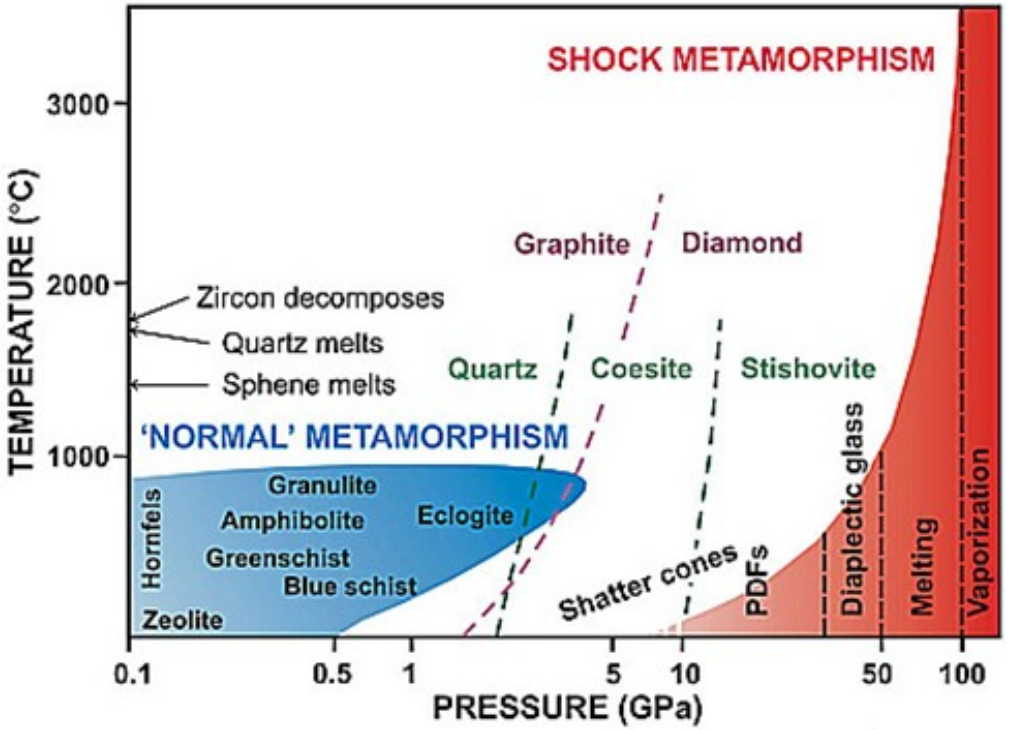
Key Question #1:
What is happening – at the atomic scale – during strong shock compression ?



- How do metal behave?
- What does "plastic deformation" mean for a brittle crystal ? a glass ?
- What is the time- and length scale for phase transformations ?

Key Question #2:
What happens when you shock compress a “real” rock ?

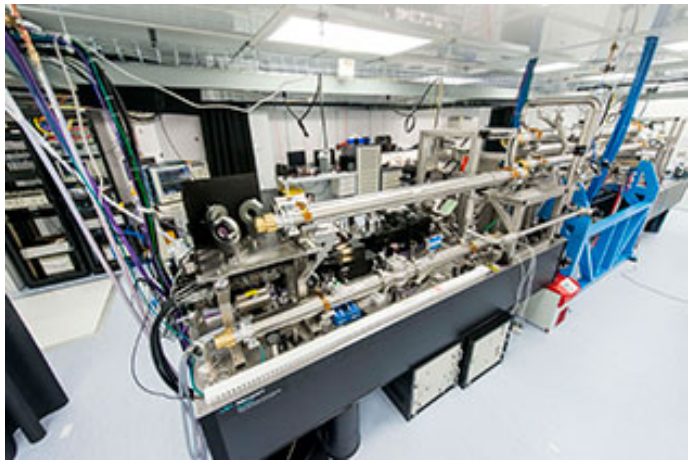




- Microscopic approach of shock metamorphism as a good example of inhomogeneous materials

Dynamic compression with sub-kJ lasers at photon facilities

- **Great potential**
- **Many very interesting questions in the Mbar range**



Acknowledgments

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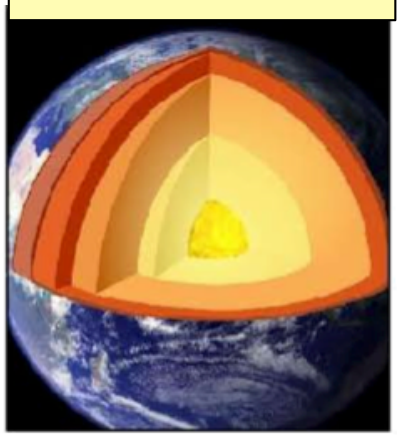
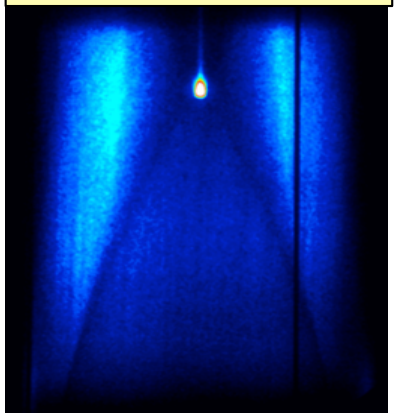
There is an annual call for proposal for (free!!) Discovery Science Experiments at the NIF

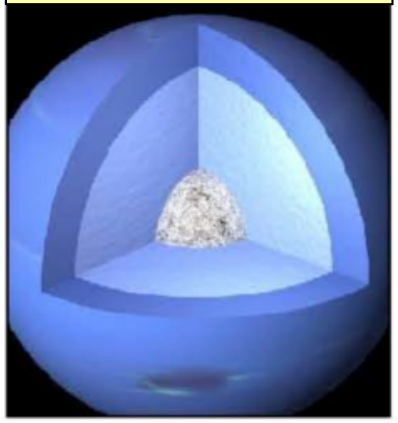
C, Fe EOS



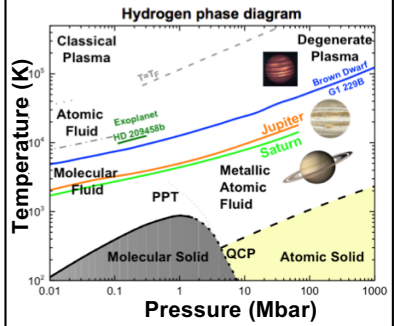
CH, HDC and near Gbar pressures



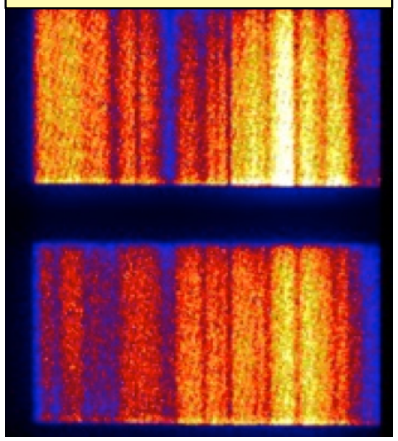
High pressure diamond phases



High pressure hydrogen properties



Planar abl. front RT instability



Eagle Nebula abl. front dynamics

Radiative shock stabilized RT

Collisionless shocks

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